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Bryophytes of Serra da Capivara National Park, Piauí, Brazil

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Abstract

Most studies of bryophytes in Brazil have focused on the Atlantic and Amazon forests, leaving the Caatinga as the biome least bryologically studied in the country. A bryofloristic survey of Serra da Capivara National Park was undertaken to analyze species richness, the distribution of species among Brazilian biomes, and the geographic distribution of species. A total of 450 samples of 62 species were collected, representing 48 mosses, 13 hepatics, and one hornwort. The resulting species list includes 22 new records for the Caatinga, 34 new records for the state of Piauí, and two for the Northeast Region of Brazil. About 60% (37 spp.) of the species have broad distributions in Brazil while 13 have moderate distributions and 12 are considered restricted. The results reinforce the importance of floristic inventories in Brazil and the maintenance of Parque Nacional da Serra da Capivara as an area for the conservation of bryophytes.

Keywords

Caatinga, liverworts, mosses.

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Introduction

Bryophytes encompass three plant divisions—mosses, hepatics, and hornworts, which share the absence of a lignified vascular system, small size, and dependence on water for sexual reproduction (Vanderpoorten and Goffinet 2009).

Floristic inventories are of paramount importance because they enable the classification of biomes, the assessment of conservation status, and the prediction of temporal and spatial changes in plant communities (Moro et al. 2014). They have also been used to infer the effects of niches on the composition of communities (Germano et al. 2016).

The Caatinga is a mosaic of prickly shrubs and seasonally dry forests (Leal et al. 2005). This biome covers about 37% of the area of the state of Piauí (Silva 2003) and has previously been described as an ecosystem poor in species richness and endemism (Andrade-Lima 1982; Prance 1987). More recent studies, however, have shown the Caatinga to be important for the conservation of Brazilian biodiversity because it has a high degree of endemism and houses several species threatened with extinction (Leal et al. 2003), which reflect its heterogeneity.

Serra da Capivara National Park (PNSC) is within a region of sierras, valleys, and plains located in the Caatinga biome in the northeastern Brazil (Pellerin 1991). It

encompasses a great variety of landscapes. This park is relatively rich biologically and harbors species with restricted geographic distributions. The vegetation is deciduous with a shrub physiognomy and some arboreal elements (Lemos and Rodal 2002). Thus, PNSC has an important role for the conservation of biodiversity.

The bryoflora of Brazil comprises approximately 1567 species (15 hornworts, 668 hepatics, and 994 mosses), while 48 species are known from the state of Piauí (Costa and Peralta 2018). Most of the studies of bryophytes in Brazil have focused on the Atlantic and Amazon forests, leaving the Caatinga as the biome least bryologically studied in the country (Zartman 2003; Visnadi 2005; Oliveira and Bastos 2009, 2010). The few works carried out in the semi-arid northeastern Brazil have been restricted to humid and sub-humid enclaves that are dispersed throughout the region (Valente and Pôrto 2006; Campelo and Pôrto 2007; Oliveira and Alves 2007).

Due to the lack of studies on bryophytes and the significance of PNSC as an important conservation unit in Piauí, the objective of the present work was to conduct a survey of its bryoflora to analyze species richness, the occurrence of species among Brazilian biomes, and the geographic distribution of species.

Methods

Study area. Serra da Capivara National Park (Fig. 1) is located in southeastern Piauí state (centered at approximately 08°26′50″S, 042°45′51″W) and includes the municipalities of São Raimundo Nonato, Coronel José Dias, João Costa, and Brejo do Piauí. The park is at the border between two of the largest geological formations of northeastern Brazil: the Middle São Francisco depression and Piauí-Maranhão sedimentary basin (Pellerin 1991). The relief is quite complex and consists of a sandstone plateau dissected by canyons, cliffs, bluffs, and valleys, with unevenness reaching 250 m (Figs 2–7). Located in the Caatinga biome, PNSC experiences a hot semi-arid climate with a high mean annual temperate (Lemos and Rodal 2002).

Sampling, herborization, and identification. Authorization for the collection and transport of specimens was approved by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio number 53182 -2).

Six field excursions were carried out between December 2016 and June 2017. Each excursion lasted two days with a daily walking time of eight hours per day on consecutive days. Collection, herborization, and preservation of material followed Gradstein et al. (2001). Random walks were performed, both on pre-existing trails and off trail, while collecting samples from all available substrates. Substrates and habitats were classified according to Fudali (2001).

We identified the samples and incorporated them into Herbário da Universidade Estadual do Piauí (HUESPI), Campus Heróis do Jenipapo, with duplicates incorporated into the Herbarium "Maria Eneyda Pacheco Kauffman Fidalgo" (SP) at the Instituto de Botânica de São Paulo.

Species identification was accomplished in consultation with Sharp et al. (1994), Yano and Carvalho (1995),

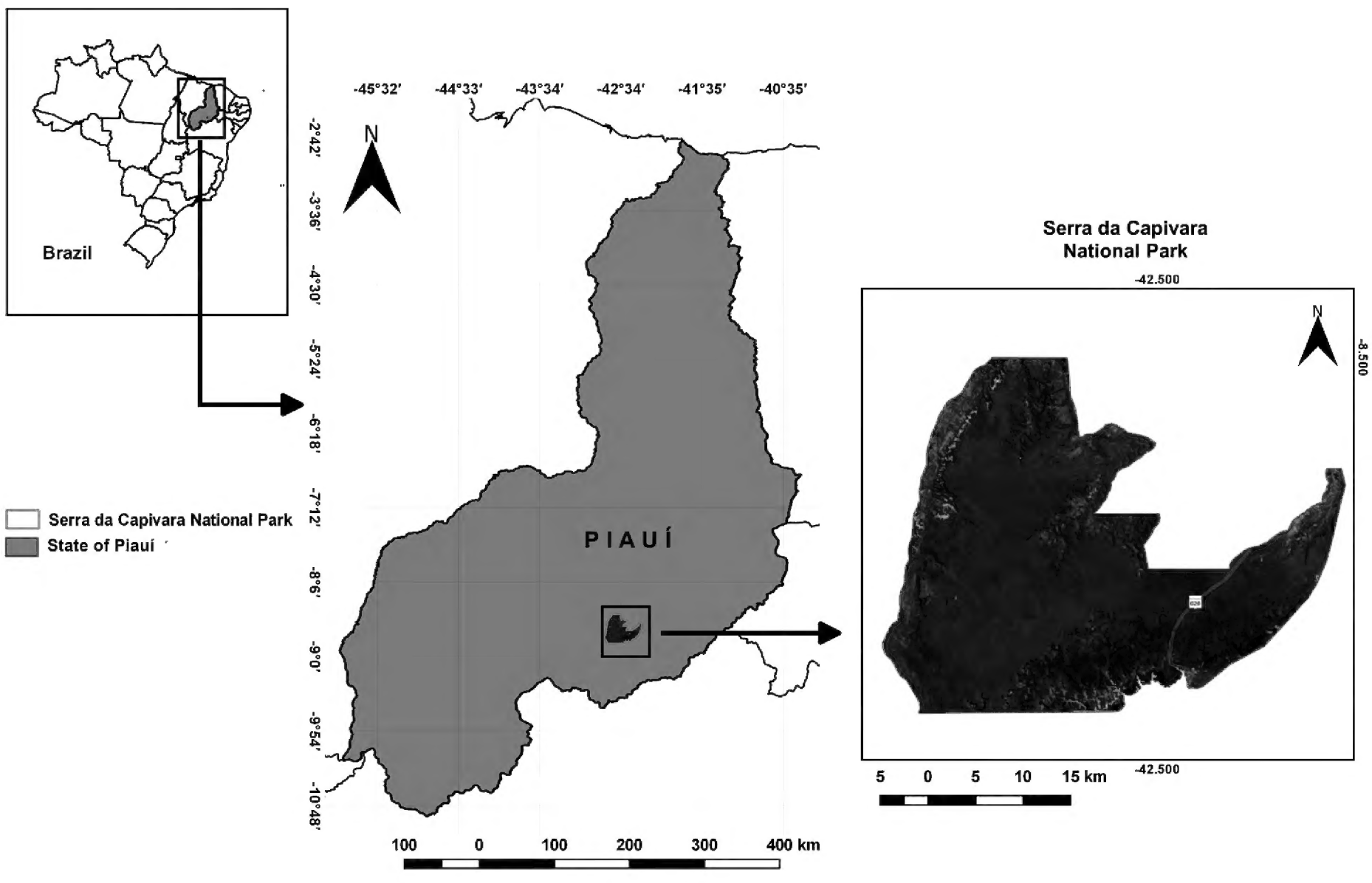

Figure 1. Geographic location of the Serra da Capivara National Park in Brazil and the state of Piauí.


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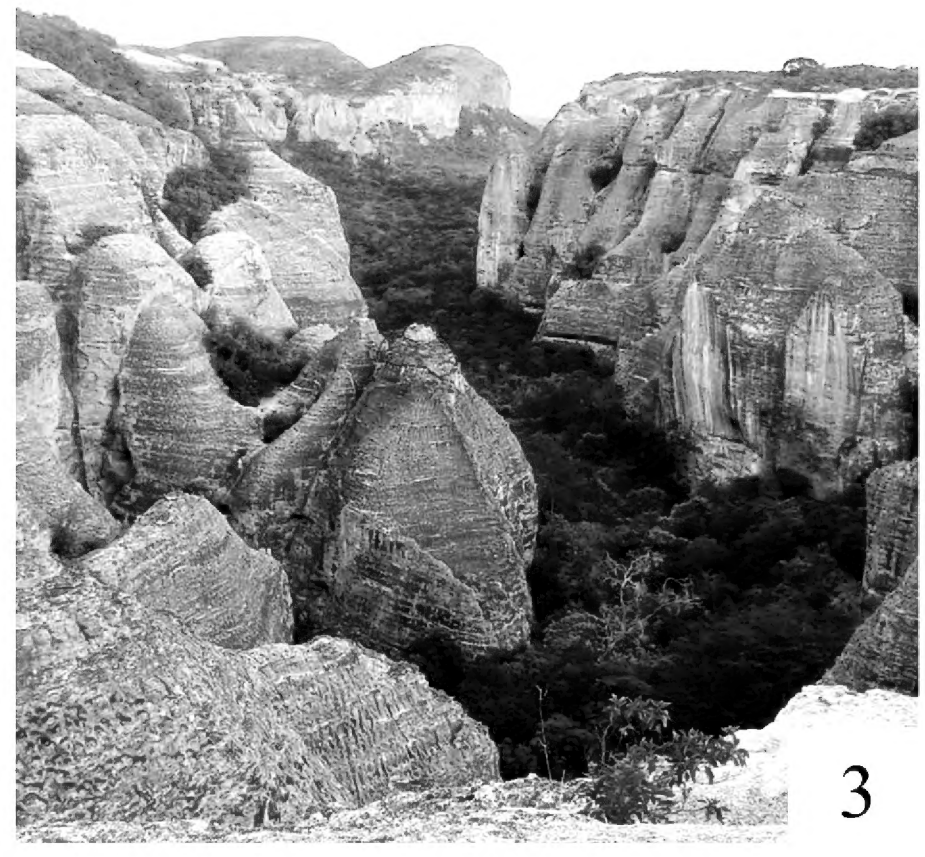
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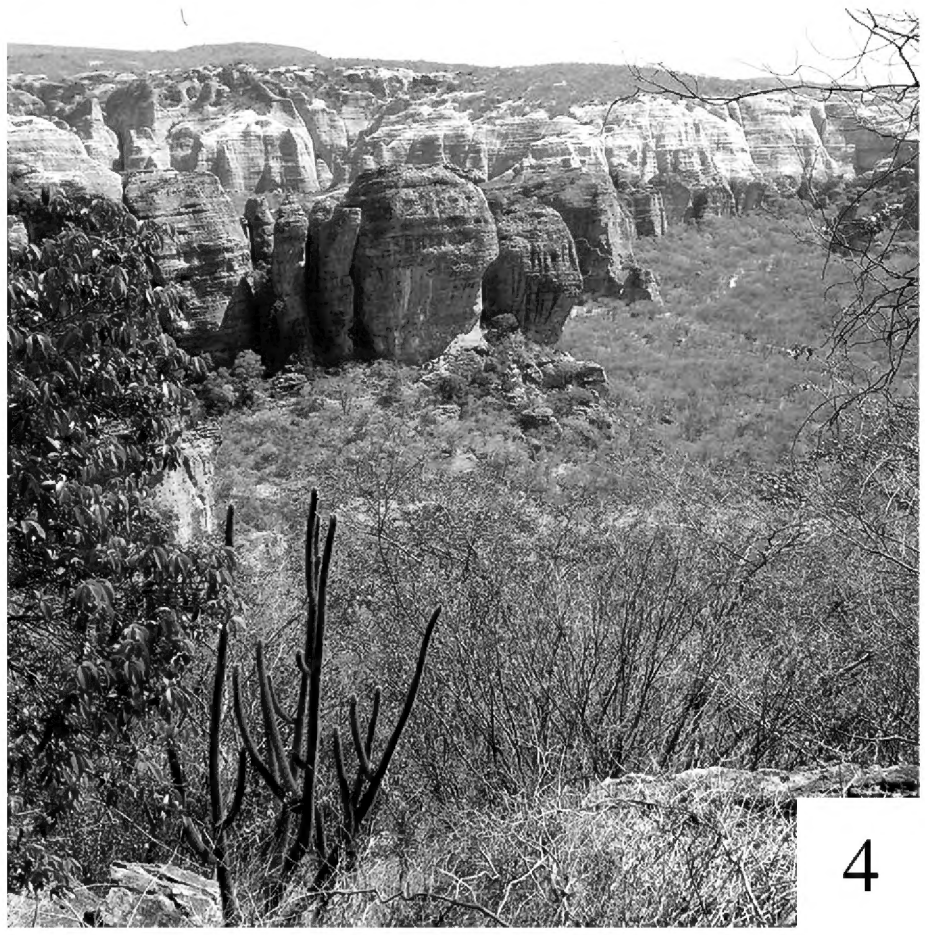
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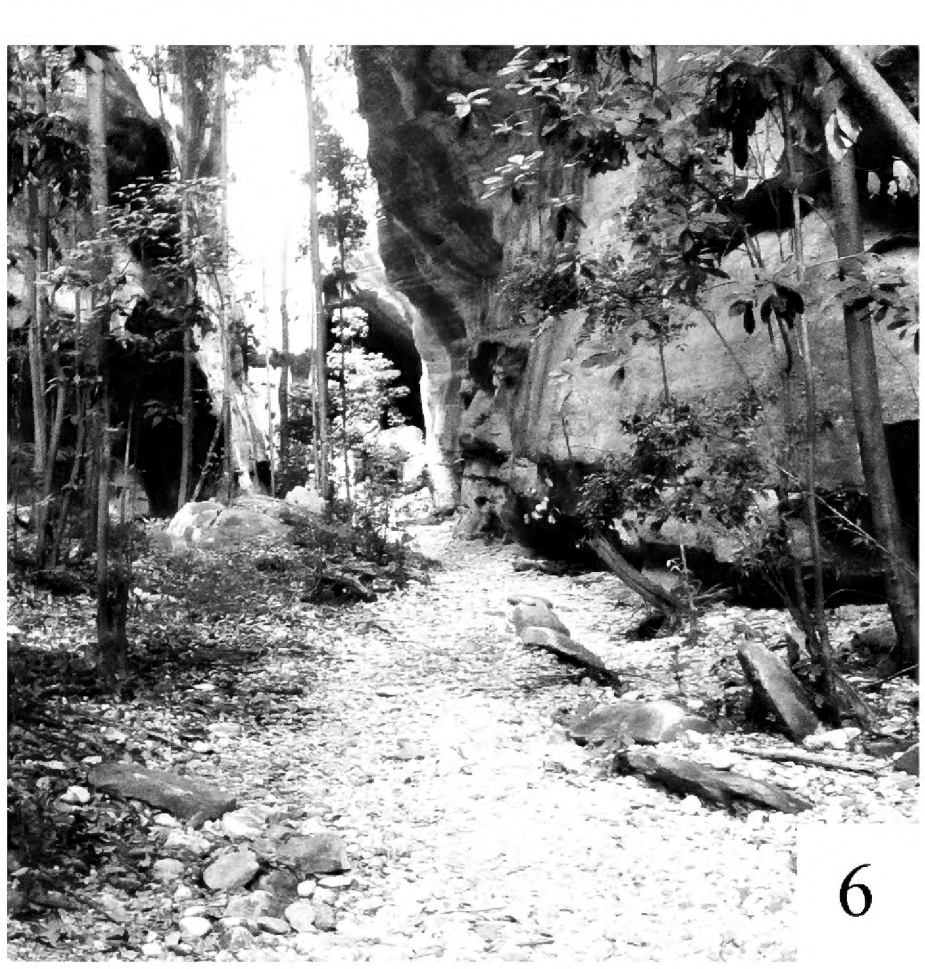
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Figures 2–7. Study area. **2, 3.** Park overview **4.** Rupestrian field **5.** Field **6.** Interior aspect of canyons **7.** Arboreal physiognomy.

Buck (1998), Bôas-Bastos and Bastos (1998), Bastos et al. (2000), Gradstein et al. (2001), Gradstein and Costa (2003), Valente et al. (2011), and Bordin and Yano (2013), along with comparisons with herbarium specimens. The classifications used were those of Renzaglia et al. (2009) for Anthocerotophyta, Crandall-Stotler et al. (2009) for Marchantiophyta, and Goffinet et al. (2009) for Bryophyta.

Brazilian geographical distributions were categorized according to Valente and Pôrto (2006), who considered bryophytes that occur in one to four Brazilian states as "restricted"; those occurring in five to nine states as "moderately distributed"; and those occurring in 10 or more Brazilian states as "broadly distributed". Also used were the Flora do Brasil 2020 (2019), complemented by the works of Gradstein and Costa (2003) and Costa and Peralta (2015).

Results

A total of 450 samples of 62 species were collected, representing 48 mosses (21 genera and 12 families), 13 hepatics (seven genera and three families) and one hornwort (*Notothylas vitalii* Udar & D.K. Singh). This is the first record of a species of Anthocerotophyta for Piauí. The species list includes 22 new occurrence records for the Caatinga, 34 for Piauí, and two for the Northeast Region of Brazil (Table 1).

The most represented moss families were Fissidentaceae (18 spp.), Bryaceae (6 spp.), and Sematophyllaceae (6 spp.). The most species-rich hepatic family was Ricciaceae (6 spp.).

Approximately 60% (37 spp.) of the taxa have broad distributions in Brazil, while 13 (21%) have moderate distributions and 12 (19%) are considered restricted (10 mosses and two hepatics).

Diagnostic characterization of new records and remarkable species are provided here in alphabetical order byfamily. Notable species are figured by photographs (Figs 8–23).

Anthocerotophyta

Family Notothyladaceae Müll. Frib. ex Prosk.

***Notothylas vitalii* Udar & D.K. Singh**, Misc. Bryol. Lichenol. 8: 173. f. 1. 1980.

Materials examined. Table 1.

Identification. Characterized by the absence of pseudoelaters and columella, and the presence of yellow spores. Habitat: rupicolous.

Table 1. List of bryophyte found in Serra da Capivara National Park. Distribution patterns in Brazil: MO = Moderate distributed, RE = Restricted, EN = endemic, and BR = Broadly distributed. Biomes = Amazon Forest = AM, Atlantic Forest = AT, Cerrado = CE, Caatinga = CA, Pampa = PP, Pantanal = PA. *New record for the state of Piauí. **New record for Caatinga. ***New record for the Northeast Region (GMGN = Géssica Maria Gomes do Nascimento).

Taxon	Distribution pattern	Biome	Voucher	Latitidue (S)	Longitude (W)
Anthocerotophyta					
Notothyladaceae					
***Notothylas vitalii* Udar & D.K. Singh (Udar and Singh 1980: 173)	BR/EN	AM, AT, CE, PA	GMGN 1045 (HUESPI499)	08°49'24"	042°29'70"
Marchantiophyta					
Cephaloziellaceae					
***Cylindrocolea rhizantha* (Mont.) R.M. Schust. (Montagne 1842: 454; Schuster 1972: 195)	MO	AM, AT, CE	GMGN 1048 (HUESPI500)	08°49'24"	042°29'70"
Corsiniaceae					
Cronisia fimbriata (Nees) Whittem. & Bischl. (Nees von Esenbeck 1833: 301; Whittemore and Bischler 2001: 170)	MO	AT, CA, CE, PA	GMGN 677 (HUESPI575)	08°49'24"	042°29'70"
Cronisia weddellii (Mont.) Grolle (Montagne 1856: 352; Grolle 1977: 532)	BR	AT, CA, CE	GMGN 692 (HUESPI549)	08°49'35"	042°33'43"
Cyathodiaceae					
Cyathodium cavernarum Kunze (Kunze 1834: 18)	MO	AT, CE	GMGN 1053 (HUESPI506)	08°49'54"	042°33'43"
Fossombroniaceae					
Fossombronia porphyrorhiza (Nees) Prosk. (Nees von Esenbeck 1833: 343; Proskauer 1955: 197)	BR	AT, CA, CE, PA	GMGN 1049 (HUESPI501)	08°49'80"	042°29'50"
Lejeuneaceae					
***Lejeunea cancellata* Nees & Mont. (Nees and Montagne 1842: 472)	BR	AT, CE, PA	GMGN 1051 (HUESPI502)	08°49'80"	042°29'50"
Ricciaceae					
**Riccia erythrocarpa* Jovet-Ast (Jovet-Ast 1991: 69)	EN/RE	CA	GMGN 1050 (HUESPI503)	08°49'24"	042°29'70"
**Riccia planobiconvexa* Steph. (Stephani 1897: 29)	BR	AT, CA, CE, PA, PP	GMGN 773 (HUESPI573)	08°49'54"	042°33'43"
***Riccia ridleyi* A. Gepp in Ridley (Ridley 1890: 74)	RE	AT	GMGN 715 (HUESPI574)	08°49'54"	042°33'43"
**Riccia stenophylla* Spruce (Spruce 1889: 195)	BR	AT, CA, CE, PA, PP	GMGN 1054 (HUESPI504)	08°49'54"	042°33'43"
Riccia vitalii Jovet-Ast (Jovet-Ast 1987: 45)	BR	AT, CA, CE	GMGN 1052 (HUESPI505)	08°49'54"	042°33'43"
**Riccia wainionis* Steph. (Stephani 1898: 326)	BR	AT, CA, CE	GMGN 961 (HUESPI578)	08°49'54"	042°33'43"

Taxon	Distribution pattern	Biome	Voucher	Latitidue (S)	Longitude (W)
Targioniaceae					
Targionia hypophylla L. (Linnaeus 1753:1136)	MO	AT, CE,	GMGN 1060 (HUESPI507)	08°49′54″	042°33′43″
Bryophyta					
Archidiaceae					
Archidium ohioense Schimp. ex Müll. Hal. (Muller 1851: 517)	BR	AT, CA, CE, PA, PP	GMGN 1046 (HUESPI508)	08°49′14″	042°29′70″
Bartramiaceae					
**Philonotis cernua* (Wils.) Griffin & Buck (Wilson 1841: 383; Griffin and Buck 1989: 376)	BR	AT, CA, CE	GMGN 1054 (HUESPI509)	08°49′24″	042°29′70″
Philonotis uncinata (Schwägr.) Brid. (Schwägrichen 1816: 57; Bridel 1827: 22)	BR	AM, AT, CA, CE, PA, PP	GMGN 1050 (HUESPI510)	08°49′24″	042°29′70″
Bryaceae					
***Brachymenium columbicum* (De Not.) Broth. (Notaris 1859: 445; Brotherus 1903: 557)	RE	AT	GMGN 1047 (HUESPI511)	08°49′57″	042°32′60″
***Brachymenium fabronioides* (Müll. Hal.) Kindb. (Müller 1879: 289; Kindberg 1889: 86)	RE	AT	GMGN 1055 (HUESPI512)	08°49′70″	042°32′50″
Bryum argenteum Hedw. (Hedwig 1801: 181)	BR	AM, AT, CA, CE, PP	GMGN 1103 (HUESPI513)	08°49′80″	042°29′50″
***Bryum arachnoideum* Müll. Hal. (Müller 1879: 378)	RE	AT	GMGN 1047 (HUESPI511)	08°49′57″	042°32′60″
Bryum capillare Hedw. (Hedwig 1801: 182)	BR	AM, AT, CE, PA, PP	GMGN 1156 (HUESPI514)	08°49′76″	042°32′50″
***Bryum leptocladon* Sull. (Sullivant 1861: 282)	RE	CE	GMGN 1157 (HUESPI515)	08°49′24″	042°29′70″
***Bryum limbatum* Müll. Hal. (Müller 1851: 573)	MO	AT, CE	GMGN 756 (HUESPI595)	08°49′24″	042°29′70″
Calymperaceae					
Calymperes palisotii Schwägr. (Schwägrichen 1816: 98)	BR	AM, AT, CA, CE	GMGN 1058 (HUESPI516)	08°49′24″	042°29′70″
Octoblepharum albidum Hedw. (Hedwig 1801: 50)	BR	AM, AT, CA, CE, PA, PP	GMGN 1060 (HUESPI517)	08°50′30″	042°33′30″
Ephemeraceae					
***Micromitrium thelephorothecum* (Florsch.) Crosby (Florschutz 1964: 67; Crosby 1968: 116)	RE	AM, AT	GMGN 826 (HUESPI602)	08°49′75″	042°32′50″
Fissidentaceae					
Fissidens angustifolius Sull. (Sullivant 1861: 275)	BR	AM, AT, CA, CE, PA, PP	GMGN 559 (HUESPI603)	08°49′24″	042°29′70″
***Fissidens bryoides* Hedw. (Hedwig 1801: 153)	RE	AT	GMGN 1059 (HUESPI518)	08°49′24″	042°29′70″
**Fissidens crispus* Mont. (Montagne 1838: 57)	BR	AM, AT, CA, CE, PA, PP	GMGN 825 (HUESPI607)	08°49′24″	042°29′70″
***Fissidens dissitifolius* Sull. (Sullivant 1861: 274)	RE	AT	GMGN 1061 (HUESPI519)	08°49′24″	042°29′70″
**Fissidens flaccidus* Mitt. (Mitten 1860: 18)	BR	AM, AT, CA, CE, PA, PP	GMGN 1065 (HUESPI520)	08°49′75″	042°32′50″
**Fissidens goyazensis* Broth. (Brotherus 1895: 120)	BR	AM, AT, CA, CE	GMGN 1062 (HUESPI521)	08°49′75″	042°32′50″
Fissidens hornschuchi Mont. (Montagne 1840: 342)	BR	AM, AT, CA, CE, PA, PP	GMGN 1064 (HUESPI522)	08°49′35″	042°33′30″
**Fissidens inaequalis* Mitt. (Mitten 1869: 569)	BR	AM, AT, CE	GMGN 707 (HUESPI613)	08°49′75″	042°32′50″
Fissidens lagenarius Mitt. (Mitten 1868: 124)	BR	AM, AT, CA, CE, PA	GMGN 1063 (HUESPI523)	08°49′79″	042°29′50″
***Fissidens leptophyllus* Mont. (Montagne 1840: 344)	MO	AM, AT, CE, PA	GMGN 1071 (HUESPI524)	08°50′37″	042°33′30″
***Fissidens palmatus* Hedw. (Hedwig 1801: 154)	MO	AM, AT CE	GMGN 1073 (HUESPI525)	08°49′24″	042°29′70″
***Fissidens perfalcatus* Broth. (Brotherus 1900: 13)	MO	AT, CE	GMGN 1069 (HUESPI526)	08°50′37″	042°33′30″
Fissidens serratus Müll. Hal. (Müller 1847: 804)	BR	AM, AT, CA, CE	GMGN 1011 (HUESPI625)	08°50′37″	042°33′30″
****Fissidens steerei* Grout (Grout 1943: 191) (Fig. 46)	RE	AT, CE	GMGN 1069 (HUESPI527)	08°50′37″	042°33′30″
Fissidens submarginatus Bruch in Krauss (Krauss 1846: 133)	BR	AM, AT, CA, CE, PA, PP	GMGN 1072 (HUESPI528)	08°50′37″	042°33′30″
****Fissidens weirii* Mitt. (Mitten 1869: 602)	MO	AT, CE	GMGN 1073 (HUESPI529)	08°49′79″	042°29′50″
***Fissidens yucatanensis* Steere (Steere 1935: 397)	RE	AT	GMGN 1076 (HUESPI530)	08°49′70″	042°33′40″
**Fissidens zollingeri* Mont. (Montagne 1845: 1414)	BR	AM, AT, CA, CE, PA	GMGN 1075 (HUESPI531)	08°49′80″	042°29′50″
Hypnaceae					
Vesicularia vesicularis (Schwägr.) Broth. (Schwägrichen 1827: 199; Brotherus 1908: 1094)	BR	AM, AT, CE, PA	GMGN 391 (HUESPI631)	08°49′80″	042°29′50″
Leucobryaceae					
***Campylopus fragilis* (Brid.) Bruch & Schimp. (Bridel 1801: 296; Bruch and Schimper 1847: 164)	EN/RE	AT	GMGN 1065 (HUESPI532)	08°49′78″	042°33′40″
Campylopus heterostachys (Hampe) A. Jaeger (Hampe 1865: 581 Jaeger 1872: 421)	BR	AM, AT, CA, CE	GMGN 1070 (HUESPI533)	08°50′37″	042°33′30″
***Campylopus julicaulis* Broth. (Brotherus 1924: 261)	EN/MO	AT, PP	GMGN 1064 (HUESPI534)	08°49′53″	042°33′30″
Pottiaceae					
Aschisma carniolicum (F. Weber & D. Mohr) Lindb. (Weber and Mohr 1807: 450; Lindberg 1878: 39)	BR	AT, CA	GMGN 1137 (HUESPI640)	08°49′68″	042°32′56″

Taxon	Distribution pattern	Biome	Voucher	Latitidue (S)	Longitude (W)
Hyophila involuta (Hook.) A. Jaeger (Hooker1819: 154; Jaeger 1873: 354)	BR	AM, AT, CA, CE, PA, PP	GMGN 942 (HUESPI641)	08°49'79"	042°29'51"
**Hyophiladelphus agrarius* (Hedw.) R.H. Zander (Hedwig 1801: 116; Zander 1995: 372)	BR	AM, AT, CA, CE	GMGN 1066 (HUESPI535)	08°49'24"	042°29'70"
**Plaubelia sprengelii* (Schwägr.) R.H. Zander (Schwägrichen 1823: 119; Zander 1993: 176)	BR	AM, AT, CA, CE	GMGN 1068 (HUESPI536)	08°49'24"	042°29'70"
**Trichostomum brachydontium* Bruch (Bruch 1829: 391)	MO	AM, AT, CA, CE	GMGN 696 (HUESPI645)	08°49'80"	042°29'50"
Trichostomum tenuirostre (Hook. & Taylor) Lindb. (Hooker and Taylor 1827: 83; Lindberg 1864: 225)	BR	AM, AT, CA, CE	GMGN 1067 (HUESPI537)	08°49'80"	042°29'50"
Sematophyllaceae					
**Sematophyllum adnatum* (Michx.) E. Britton (Michaux 1803: 310-311; Britton 1902: 65)	BR	AM, AT, CA, CE	GMGN 1074 (HUESPI538)	08°50'37"	042°33'45"
Sematophyllum subsimplex (Hedw.) Mitt. (Hedwig 1801: 11-14; Mitten 1869: 492)	BR	AM, AT, CA, CE, PA	GMGN 1076 (HUESPI539)	08°49'80"	042°29'50"
Trichosteleum hornschuchii A. Jaeger (Jaeger 1878: 484)	MO	AM, AT, CA, CE	GMGN 1077 (HUESPI541)	08°50'37"	042°33'25"
Trichosteleum subdemissum (Schimp. ex Besch.) A. Jaeger (Schimper 1876: 250; Jaeger 1878: 418)	BR	AM, CE, AT	GMGN 1075 (HUESPI543)	08°50'37"	042°33'45"
Splachnobryaceae					
***Splachnobryum obtusum* (Brid.) Müll. Hal. (Bridel 1806: 118; Müller 1869: 504)	MO	AM, AT, CE, PA	GMGN 889 (HUESPI654)	08°49'55"	042°32'52"
Stereophyllaceae					
Entodontopsis leucostega (Brid.) Buck & Irel. (Bridel 1827: 333; Buck and Ireland 1985: 103)	BR	AM, AT, CA, CE, PA	GMGN 1014 (HUESPI655)	08°49'34"	042°33'42"
***Eulacophyllum cultelliforme* (Sull.) W.R.Buck & Ireland (Sullivant 1861: 289; Buck and Ireland 1985: 108)	BR	AM, AT, CE, PA	GMGN 797 (HUESPI656)	08°49'78"	042°33'31"

Brazilian range. AC, AM, BA, CE, GO, MA, MS, MT, PE, SP. New record for Caatinga.

Bryophyta

Family Bartramiaceae Schwägr.

***Philonotis cernua* (Wils.) Griffin Buck**, Bryologist 92 (3): 376. 1989.

Materials examined. Table 1. Fig. 8.

Identification. Characterized by narrow-lanceolate leaves, acuminate and denticulate apex; clear distal papillae, long-rectangular base cells; row of simple, denticulate margin cells; excurrent costa. Habitat: rupicolous.

Brazilian range. CE, DF, GO, MA, MG, MT, PB, PR, RJ, RS, SC, SE, SP.

Family Bryaceae Schwägr.

***Brachymenium columbicum* (De Not.) Broth.**, Nat. Pflanzenfam. I(3): 557. 1903.

Materials examined. Table 1.

Identification. Identified by oblong-lanceolate leaves equally disposed throughout the stem and denticulate margin in upper median portion; leaves erect to imbricate when dry. Habitat: rupicolous, terricolous.

Brazilian range. CE, SP. New record for Caatinga.

***Brachymenium fabronioides* (Dozy & Molk.) Bosch & Sande Lac.**, Enum. Bryin. Exot., Suppl. 1:86. 1889.

Materials examined. Table 1. Fig. 9.

Identification. Characterized by shiny leaves and linear to linear-vermicular cells of the margin. Habitat: rupicolous.

Brazilian range. BA, ES. New record for Caatinga.

***Bryum arachnoideum* Müll. Hal.**, Flora 62: 378. 1879.

Materials examined. Table 1. Fig. 10.

Identification. Characterized by small plants forming tufts; greenish-yellow julaceous leaves and percurrent costa. Habitat: rupicolous.

Brazilian range. BA, MG, PE, SE. New record for Caatinga.

***Bryum leptocladon* Sull.**, Proc. Amer. Acad. Arts 5: 282. 1861.

Materials examined. Table 1. Fig. 11.

Identification. Distinguished by rhomboidal-hexagonal lamina cells; small capsules and smooth spores. Habitat: rupicolous.

Brazilian range. BA, CE, DF, GO. New record for Caatinga.

***Bryum limbatum* Müll. Hal.**, Syn. Musc. Frond. 2: 573. 1851.

Materials examined. Table 1. Fig. 12.

Identification. Distinguished by denticulate margin of upper median portion of leaves. Habitat: rupicolous and corticolous.

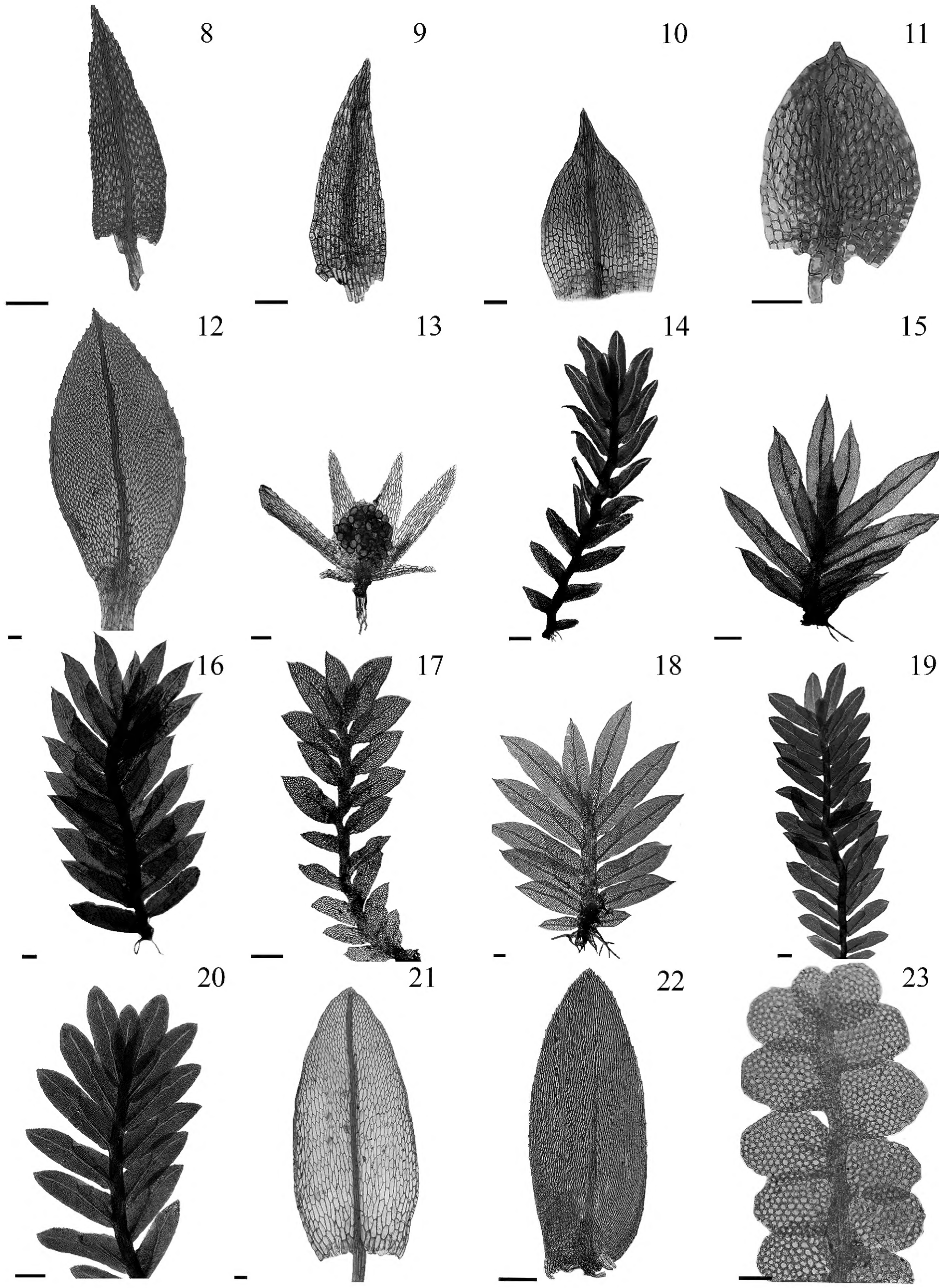
Brazilian range. DF, ES, MG, MS, PR, RJ, RS, SC, SP. New record for Caatinga.

Family Ephemeraceae J.W. Griff. & Henfr.

***Micromitrium thelephorothecum* (Florsch.) Crosby**, Bryologist 71: 116. 1968.

Materials examined. Table 1. Fig. 13.

Identification. Differentiated by reduced size with lanceolate leaves; long hexagonal medial and distal cells; large and broad irregularly-rectangular basal cells; ovoid and rugose capsule. Habitat: terricolous.



Figures 8-23. Bryophytes of Serra da Capivara National Park. **8.** *Philonotis cernua* (Wils.) Griffin & Buck. **9.** *Brachymenium fabronioides* (Müll. Hal.) Kindb. **10.** *Bryum arachnoideum* Müll. Hal. **11.** *Bryum leptocladon* Sull. **12.** *Bryum limbatum* Müll. Hal **13.** *Micromitrium thelephorothecum* (Florsch.) Crosby. **14.** *Fissidens bryoides* Hedw. **15.** *Fissidens dissitifolius* Sull. **16.** *Fissidens goyazensis* Broth. **17.** *Fissidens inaequalis* Mitt. **18.** *Fissidens leptophyllus* Mont. **19.** *Fissidens perfalcatus* Broth. **20.** *Fissidens steerei* Grout. **21.** *Splachnobryum obtusum* (Brid.) Müll. Hal. **22.** *Eulacophyllum cultelliforme* (Sull.) W.R.Buck & Ireland. **23.** *Lejeunea cancellata* Nees & Mont. Scale bars = 100 µm.

Brazilian range. MT, PA, PE, RO. New record for Caatinga.

Family Fissidentaceae Schimp.

***Fissidens bryoides* Hedw.**, Sp. Musc. Frond. 153. 1801.

Materials examined. Table 1. Fig 14.

Identification. Characterized by the absence of hyaline axillary nodules in the stem; unistratose limbidium not confluent with the costa apex in all leaves. *Fissidens bryoides* resembles *F. crispus* Mont. by the limbidium of leaves, however, hyaline axillary nodules differentiate it from this species, which has larger cells with thick and sinuous walls and generally longer leaves. Habitat: rupicolous and terricolous.

Brazilian range. PE, PR, SP. New record for Caatinga.

***Fissidens crispus* Mont.**, Ann. Sci. Nat., Bot. 2 9: 57. 1838.

Materials examined. Table 1.

Identification. Recognized by the presence of hyaline axillary nodules on the stem; oblong-ovate entirely limbate leaves, sometimes crispate when dry; smooth cells with thick walls. *Fissidens crispus* resembles *F. bryoides* Hedw., which has smaller cells without thick walls. Habitat: terricolous.

Brazilian range. AM, BA, CE, DF, ES, GO, MG, PE, PR, RJ, RO, RR, RS, SC, SP, TO.

***Fissidens dissitifolius* Sull.**, Ann. Sci. Nat., Bot. 2 9: 57. 1838.

Materials examined. Table 1. Fig. 15.

Identification. Characterized by small flabellate gametophytes; generally crispate leaves when dry, with limbidium throughout the lamina usually ending before the apex. Habitat: rupicolous and terricolous.

Brazilian range. BA, PR, SP. New record for Caatinga.

***Fissidens flaccidus* Mitt.**, Trans. Linn. Soc. London 23: 56. 6 f. 18. 1860.

Materials examined. Table 1.

Identification. Identified by flabellate gametophytes; long lanceolate leaves with limidium entirely confluent with the apex; smooth pentagonal or hexagonal cells with sinuous walls. It is similar to *Fissidens palmatus* Hedw., which is smaller (generally 2–4 mm alt.), and has cells with straight walls and limbidium not confluent with the apex. Habitat: rupicolous.

Brazilian range. AC, AM, BA, CE, DF, ES, GO, MA, MG, MS, MT, PA, PB, PE, PR, RJ, RO, RS, SE, SP, TO.

***Fissidens goyazensis* Broth.**, Hedwigia 34: 120. 1895.

Materials examined. Table 1. Fig. 16.

Identification. Characterized by acuminate and completely limbate oblong-lanceolate leaves; excurrent costa; unipapillose cells. *Fissidens goyazensis* resembles *F. angustifolius* Sull., however, this species has larger, pellucid, quadratic to rectangular cells of vaginate laminae and generally precurrent, not excurrent, costa. Habitat: rupicolous and terricolous.

Brazilian range. AM, BA, CE, PB, PE, PI, DF, GO, MG, RJ, SP.

***Fissidens inaequalis* Mitt.**, J. Linn. Soc., Bot. 12: 569. 1869.

Materials examined. Table 1. Fig. 17.

Identification. Recognized by the reduced size of the gametophytes; leaves with dimorphic cells; large, guttulate, clear, rhomboidal-hexagonal lamina cells; reduced and isodiametric marginal cells forming a margin with 1–3 rows of differentiated cells; limbidium absent. It differs from *Fissidens ornatus* Herzog because this species has a serrated margin, never smooth or crenulate and an acute apex. Habitat: rupicolous and terricolous.

Brazilian range. AM, BA, GO, MA, MG, MT, PB, PE, RJ, RO, RR, SE, SP.

***Fissidens leptophyllus* Mont.**, Ann. Sci. Nat., Bot. 2 14: 344. 1840.

Materials examined. Table 1. Fig. 18.

Identification. Recognized by oblong-ovoid leaves with very acute apex; costa up to 2–4 cells below the apex; unipapillose cells; limbidium in vaginate lamina of all leaves. Easily confused with *F. submarginatus* Bruch, but this species has oblong leaves and the limbidium occupies the full extent of the vagnate lamina. Habitat: rupicolous, terricolous and termitocolous.

Brazilian range. AC, AM, BA, GO, MA, MG, SP. New record for Caatinga.

***Fissidens palmatus* Hedw.**, Sp. Musc. Frond. 154. 1801.

Materials examined. Table 1

Identification. Diagnosed by non-sinuous walls of the cells of the leaves lamina and differentiated cells in the mid-region.

Brazilian range. AC, BA, CE, GO, MA, PB, PE, SP. New record for Caatinga.

***Fissidens perfalcatus* Broth.**, Bih. Kongl. Svenska Vetensk.-Akad. Handl. 26, Afd. 3(7): 13. 1900.

Materials examined. Table 1. Fig. 19.

Identification. Characterized by oblong-ovoid leaves with vaginate lamina that covers the entire stem and usually surpasses it; limbidium occupying the entire extension or until the vaginate lamina of all the leaves; unipapillose cells. It differs from *F. submarginatus* Bruch, which has oblong-lanceolate leaves; vaginate lamina covering part of the stem, never surpassing it; limbidium occupying the full extent of the vaginate lamina. Habitat: rupicolous, terricolous and termitocolous.

Brazilian range. BA, ES, GO, MT, PB, PE, TO. New record for Caatinga.

***Fissidens steerei* Grout**, N. Amer. Fl. 15: 191. 1943.

Materials examined. Table 1. Fig. 20.

Identification. Identified by delicate gametophytes and elimbate leaves with strongly obtuse apex. Can be confused with *Fissidens serratus* Müll. Hal., however, the latter has a strongly serrated margin and gradually acute

apex of the phyllidia. Habitat: rupicolous and terricolous.

Brazilian range. GO, SP. New record for Caatinga.

***Fissidens weirii* Mitt.**, J. Linn. Soc., Bot. 12: 602. 1869.

Materials examined. Table 1.

Identification. Characterized by entirely limbate oblong-lanceolate leaves with limbidium ending before the apex; pluripapillose cells mainly in the apical region. Habitat: rupicolous, terricolous and epigaeous.

Brazilian range. GO, MG, PR, RJ, RS, SC, SP. New record for Caatinga.

***Fissidens yucatanensis* Steere**, Amer. J. Bot. 22: 397. 1935.

Materials examined. Table 1.

Identification. Characterized by lanceolate leaves, acute apex with hyaline or reddish cells, unipapillose. It resembles *Fissidens angustifolius* Sull. and *Fissidens goyazensis* Broth. However, *F. angustifolius* has precurrent costa, limbidium not terminating below the apex and the absence of hyaline apical cells, whereas *F. goyazensis* differs by ligulate leaves and percurrent to excurrent costa. Habitat: rupicolous and terricolous.

Brazilian range. CE, PA, PB. New record for Caatinga.

***Fissidens zollingeri* Mont.**, Ann. Sci. Nat., Bot. 34: 114. 1845.

Materials examined. Table 1.

Identification. Recognized by large, long-rectangular, pellucid cells in the mid region of the vaginate lamina; oblong-lanceolate completely limbate leaves. It resembles *F. bryoides* and *F. crispus*, however, the former has percurrent costa and shorter leaves, while the latter has percurrent costa or ending a few cells below the apex, and dentate margin of the apex and dorsal lamina. Habitat: rupicolous and terricolous.

Brazilian range. AC, AL, AM, BA, CE, DF, ES, GO, MA, MG, MS, MT, PA, PB, PE, PR, RJ, RO, RR, RS, SC, SE, SP, TO.

Family Leucobryaceae Schimp.

***Campylopus fragilis* (Brid.) Bruch & Schimp.**, Bryol. Eur. 1: 164. 1847.

Materials examined. Table 1.

Identification. Diagnosed by green, erect and rarely branched gametophytes; costa occupies between ⅓ and ⅔ of the width of the base of the leaf; excurrent with ventral hyalocysts and undifferentiated wing region. Habitat: rupicolous and terricolous.

Brazilian range. MG, RJ. New record for Caatinga.

***Campylopus julicaulis* Broth.**, Ergebn. Bot. Exp. Südbras., Musci 261. 1924.

Materials examined. Table 1.

Identification. Recognized by thin leaves and tomentose gametophytes. It resembles *Campylopus occultus* Mitt., but does not possess hyaline basal cells of the laminae. Habitat: rupicolous and terricolous.

Brazilian range. BA, MG, PR, RJ, RS, SC, SP. New record for Caatinga.

Family Pottiaceae Hampe

***Hyophiladelphus agrarius* (Hedw.) R.H. Zander**, Bryologist 98: 372. 1995.

Materials examined. Table 1.

Identification. Identified by leaves with elongate and smooth costa cells on ventral and dorsal surfaces and the presence of stereids above and below the guide cells in transversal section. Habitat: rupicolous.

Brazilian range. AC, AM, BA, CE, DF, MA, MT, PA, PB, PE, RJ, RN, RO, RS, SE, SP, TO.

***Plaubelia sprengelii* (Schwägr.) R.H. Zander**, Bull. Buffalo Soc. Nat. Sci. 32: 176. 1993.

Materials examined. Table 1.

Identification. Characterized by square to rounded cells covering the ventral surface of the costa and the presence of mamillose cells in the apex of the leaves. It is similar to *Hyophiladelphus agrarius* (Hedw.) R.H.Zander, however, the presence of mamillose cells in the apex of the leaf differentiates them. Habitat: rupicolous.

Brazilian range. AC, AM, RO, BA, MA, PE, GO, MT, MG, RJ, SP.

***Trichostomum brachydontium* (Schimp. ex Besch.) A. Jaeger**, Flora 12: 393, pl. 3. 1829.

Materials examined. Table 1.

Identification. Characterized by erect, non-branched stem with central axis in transverse section and flexuose leaves. It resembles *Tortella humilis* (Hedw.) Jenn. when it is sterile, but can be differentiated by having longer stems and non-fragile leaves. Habitat: rupicolous.

Brazilian range. BA, ES, GO, PA, PE, RO.

Family Sematophyllaceae Broth.

***Sematophyllum adnatum* (Michx.) E. Britton**, Bryologist 5: 65. 1902.

Materials examined. Table 1.

Identification. Recognized by narrow-lanceolate leaves, concave lamina, acuminate apex; inflated supra-alar cells. Habitat: rupicolous, terricolous and epigaeous.

Brazilian range. AM, BA, DF, ES, GO, MA, MG, MS, MT, PA, RJ, RN, SP, TO.

Family Splachnobryaceae A.K. Kop.

***Splachnobryum obtusum* (Brid.) Müll. Hal.**, Verh. K.K. Zool.-Bot. Ges. Wien, 19: 504. 1869.

Materials examined. Table 1. Fig. 21.

Identification. Distinguished by oblong to ligulate leaves with smooth to slightly crenulate margin of the apex. Habitat: rupicolous.

Brazilian range. AC, AL, AM, AP, CE, GO, MS, RS, SP. New record for Caatinga.

Family Stereophyllaceae W.R. Buck & Ireland

***Eulacophyllum cultelliforme* (Sull.) W.R.Buck & Ireland**, Nova Hedwigia 41: 108. 1985.

Materials examined. Table 1. Fig. 22.

Identification. Characterized by obtuse to ovate-oblong phyllidia irregularly serrated at the apex; simple costa; and distal papillae in lamina cells. Habitat: rupicolous and corticolous.

Brazilian range. AM, BA, ES, MG, MS, MT, PB, PE, PR, RJ, SP, TO. New occurrence record for Caatinga.

Marchantiophyta
Family Cephaloziellaceae Douin

***Cylindrocolea rhizantha* (Mont.) R.M. Schust.**, Nova Hedwigia 22(1–2): 175. 1971.

Materials examined. Table 1.

Identification. Recognized by succubous leaves with subquadratic median cells and two lobes with sharp tips. Habitat: rupicolous.

Brazilian range. AC, BA, ES, GO, PE, RJ, SP. New record for Caatinga.

Family Lejeuneaceae Cavers

***Lejeunea cancellata* Nees & Mont.**, Hist. Phys. Cuba, Bot., Pl. Cell. 472. 1842.

Materials examined. Table 1. Fig. 23.

Identification. Characterized by orbiculate to ovoid underleaves, cuneate base; cells with evident intermediate thickening. Habitat: corticolous.

Brazilian range. BA, MS, RJ, SC, SP. New record for Caatinga.

Family Ricciaceae Rchb.

***Riccia erythrocarpa* Jovet-Ast**, Cryptog. Bryol. Lichénol. 12: 257. pl. 39–40, 69: 1–5. 1991.

Materials examined. Table 1.

Identification. Differentiated by thickened walls of the dorsal epidermal cells and rounded spores. Habitat: rupicolous and terricolous.

Brazilian range. BA, PE.

***Riccia planobiconvexa* Steph.,** Bih. Kongl. Svenska Vetensk.-Akad. Handl. 23: 29. 1897.

Materials examined. Table 1.

Identification. Identified by reddish-brown spores devoid of alae. Habitat: terricolous.

Brazilian range. AL, BA, CE, DF, ES, GO, MT, PE, PR, RJ, RN, RS, SC, TO.

***Riccia ridleyi* A. Gepp**, J. Linn. Soc., Bot. 27: 74. 1890.

Materials examined. Table 1.

Identification. Differentiated by the purple margin of the lobe. Habitat: rupicolous and terricolous.

Brazilian range. PE. New record for Caatinga.

***Riccia stenophylla* Spruce**, Bull. Soc. Bot. France 36: 195. 1889.

Materials examined. Table 1.

Identification. Differentiated by very narrow thallus segments, 0.3–0.5 mm wide. Habitat: terricolous.

Brazilian range. BA, CE, ES, GO, MA, MS, MT, PB, PE, PR, RJ, RS, SC, SP.

***Riccia wainionis* Steph.**, Bull. Soc. Bot. France 36: 195. 1889.

Materials examined. Table 1

Identification. Characterized by the colorless margin of the lobule and spores with 7 to 9 areolas of diameter. Habitat: terricolous.

Brazilian range. BA, CE, ES, MG, PB, PE, PR, RJ, SE, SP.

Discussion

Comparing the new data with those presented by Costa and Peralta (2015) reveals that the species of bryophytes found in PNSC represent 62% of the species recorded for the Caatinga and 9% of all the species recorded for the Northeast Region of Brazil; these are significant numbers for the group in this region.

Costa and Peralta (2015) suggest that the Pampa (120 spp.) and Caatinga (96 spp.) are the least bryologically rich biomes in Brazil. However, with the addition of 22 newly recorded species for the Caatinga, the number of bryophyte species of Caatinga nearly equals that of the Pampa biome, which indicates that the bryoflora of the Caatinga is still underestimated (Iganci et al. 2011).

Other studies in Caatinga areas have, as in the present study, found greater species richness of mosses than hepatics (Bastos et al. 1998; Correia et al. 2015; Valente et al. 2017). This is probably due to the morphological complexity of mosses, which provides potential for occupying various environments (Goffinet et al. 2009).

Notothylas vitalii Udar and D.K. Singh, which is endemic to Brazil, was found growing on rocky substrate and on soggy soil, two places that remain moist for much of the year. This species has been previously recorded in the Northeast Region in the states of Bahia, Ceará, Maranhão, and Pernambuco according to Flora do Brasil 2020 (2019), but no representative of the phylum Bryophyta has been recorded for state of Piauí, until now.

Fissidentaceae was the most-represented family in the present work. This family was also well represented in the studies of Castro et al. (2002), Correia et al. (2015), Carmo and Peralta (2016), and Rios et al. (2016). Bryaceae was the second richest moss family in the present study, representing approximately 13% of the bryophyte species found. According to Spence and Ramsay (2006), members of this family colonize the most diverse habitats, from hot and disturbed environments to those that are extremely humid. Representatives of this family seem to have a great ability to colonize rock surfaces, which makes them important pioneer species (Silva and Germano 2013).

With regard to distribution patterns, it is noteworthy that the hepatic *Riccia erythrocarpa* Jovet-Ast, a Caatinga endemic, had previously only been reported from the states of Bahia and Pernambuco (Forzza 2010).

The relatively high number of species found, the species previously unknown for the state, and the relatively high number of Brazilian endemic species, reinforce the importance of Serra da Capivara National Park within the national conservation unit system, with environments especially favorable for the development of bryophyte diversity.

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Authors' Contributions

GMGN collected the data, wrote the text, and made the identifications; GMC reviewed the text; DFP and HCO confirmed the identifications and reviewed the text.

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